Mechanical and Structural Theory

Course No. 108

FOR WHOM INTENDED This course is intended for individuals whose primary formal training is not in the field of mechanical or structural engineering. Mechanical and structural considerations are fundamental to almost every technical activity, and all technical personnel have to deal, at least to some extent, with some aspects of mechanical engineering. A basic understanding of mechanical principles is essential to better perform their main function.

OBJECTIVES To help participants to understand basic mechanical and structural concepts and terminology. It is not an in-depth mechanical engineering course but rather a course aimed at individuals who require an intensive review of basic principals, without the assumption of any prior knowledge of the topic. The course is fast paced and as non-mathematical as possible.

BRIEF DESCRIPTION OF COURSE The course covers basic concepts of mechanical theory, starting with basic mathematics and conversion factors. To fully comprehend sinusoidal and non-sinusoidal waveforms, a basic understanding of complex algebra is required. The instructor reviews this topic as it applies to mechanical technology.

The instructor next introduces the basics of mechanical and structural theory, such as measurement of mass, displacement, acceleration and velocity, before moving into somewhat greater depth on dynamics theory. Single and multiple degree-of-freedom systems are considered, in regard to spring stiffness, dynamic properties of different materials, natural frequency and damping.

The Rayleigh and Dunkerley methods of calculating the first natural frequency of systems are briefly considered, with examples. Forced vibration and loading effects are also included in the dynamics theory section.

Moving on to structural design fundamentals, the instructor addresses the concepts of stress and strain; moment of inertia and the torsional shape factor. Useful formulas are provided for calculating stiffness and stress, also tables for determining moments of inertia and torsional shape factors. The instructor discusses the dynamic characteristics of structural elements such as compression members, flanges and beams. Finally, the course provides useful tables and formulas for the calculation of beam stiffness and resonant frequency, as well as resonances of plates and columns.

RELATED COURSES TTi Course 310, Mechanical Design for Product Reliability, which is available as an OnDemand Complete Internet Course, contains all the theory contained in this course, plus advanced examples and exercises in applying the theory.

DIPLOMA PROGRAMS: This may be used as an optional course for any TTi Specialist Diploma Program.

PREREQUISITES: There are no definite prerequisites. However, this course is aimed toward individuals involved in various technical fields. An understanding of basic algebra will be useful.

TEXT Each student will receive 180 days access to the on-line electronic course workbook. Renewals and printed textbooks are available for an additional fee

COURSE HOURS, CERTIFICATE AND CEUs Class hours/days for on-site courses can vary from 14–35 hours over 2–5 days as requested by our clients. Upon successful course completion, each participant receives a certificate of completion and one Continuing Education Unit (CEU) for every ten class hours.

Course Outline

- Overview of Mathematics
  - Reference/Formulas/Conversion Factors • Algebra
  - Geometry, Vectors, Complex Numbers, Calculus
- Introduction to Vibration
  - Design and Testing for Vibration and Shock
  - Rotational Unbalance Example—Automobile engine
  - Vibration and Shock Examples
  - Natural Frequency (Resonance) • Forcing Frequency
  - Prolonged Excitation of Natural Frequency
  - Tacoma Narrows Bridge •
  - Effects of Shock and Vibration • Dynamic Inputs
  - Fragility • Effect of Failures
- Introduction to Mechanical Terms and Material Properties
  - Laws of Motion, Weight vs. Mass • Gravity • Density
  - Force, Mass and Acceleration
  - Engineering Materials • Tension and Compression
  - Stress and Strain • Shear • Elasticity • Tensile Strength
  - Torque • Mass and Area Moments of inertia
  - Torsional Stiffness • Torsional Shape Factors
- Application of Vibration Theory
  - Principles of Analysis • Fundamentals of Dynamics
  - Stiffness • Mass • A Simple Dynamic System
  - Degrees of Freedom • Displacement • Velocity
  - Acceleration • Natural Frequency
  - Sinusoidal Waveform
  - Modeling Complex (MDoF) Systems
  - Dunkerley's and Rayleigh's Methods
  - Transmissibility • Isolation
- Materials and Beams
  - Overall & Design-Limiting Material Properties
  - Application-Specific Material Properties
  - Simple Beam • Bending Moment • Elastic Deflection
  - Sandwich Structures • Bending Strengths
  - Structural Beams • Bending Stiffness of a Beam K_b
  - Uniformly Loaded Beam • Composite Beam Stiffness
  - Beam Instability—Twisting • Compression Member Instability • Instability of Flanges • Flange Buckling
  - Structure Buckling • Resonant Frequencies of Flanges
- Frequency and Stiffness Considerations in Plates and Beams
  - Frequency Oscillation of a Rod
  - Natural Frequency of a Simply Supported Beam
  - Natural Frequency of a Cantilever • Effective Mass
  - Natural Frequency of Simply Supported Plate
  - Beam Formulas • Stiffness of Gussets—with End load
  - Effective Stiffness of Gusset • Plate Frequency Equation
  - Column Resonance • Axial Resonance
  - Example: Determining Stress in a Loaded Beam
- Conclusion • Final Review
- Award of Certificates for successful completion

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